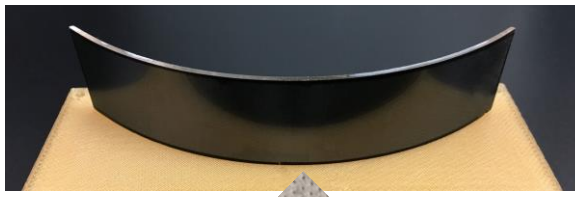
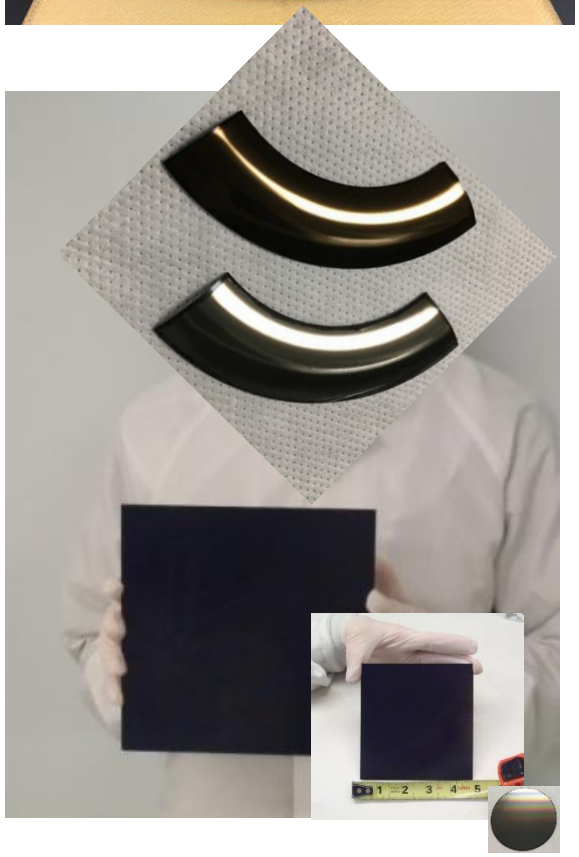
An Update on HRPPD/LAPPD Application Specific Developments for EIC

A. Lyashenko (on behalf of Incom Inc.)

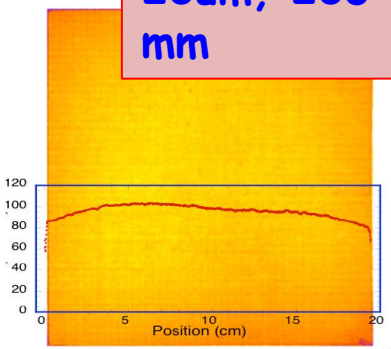
INCOM
BRIGHT IDEAS

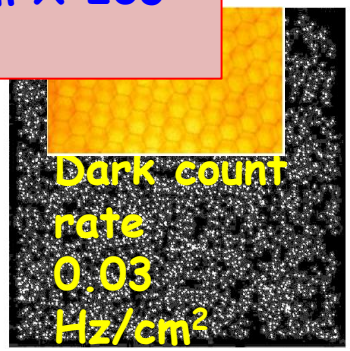
Enabling Technology: GCA-ALD-MCP





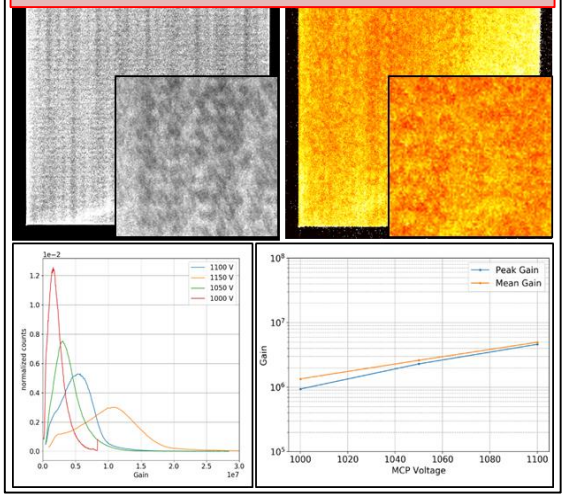
20um, 203 mm X 203 mm



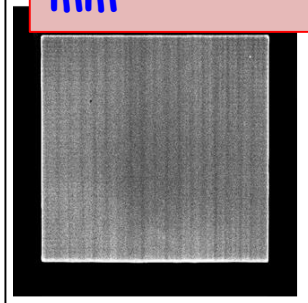


O. H. W. Siegmund et. al., SPIE Proc. 10397

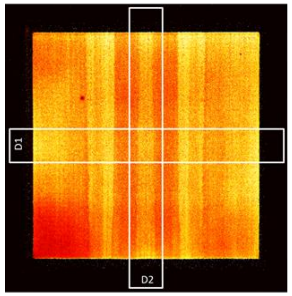
10um, 108 mm X 108 mm



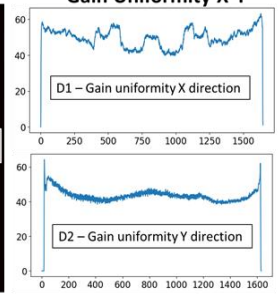
10um, 203 mm X 203 mm



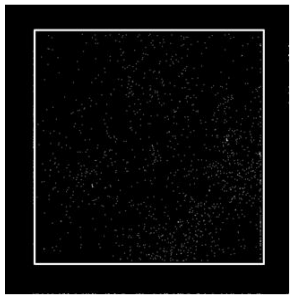
Gain Map



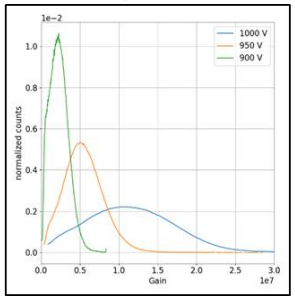
Gain Uniformity X-Y



Background Map



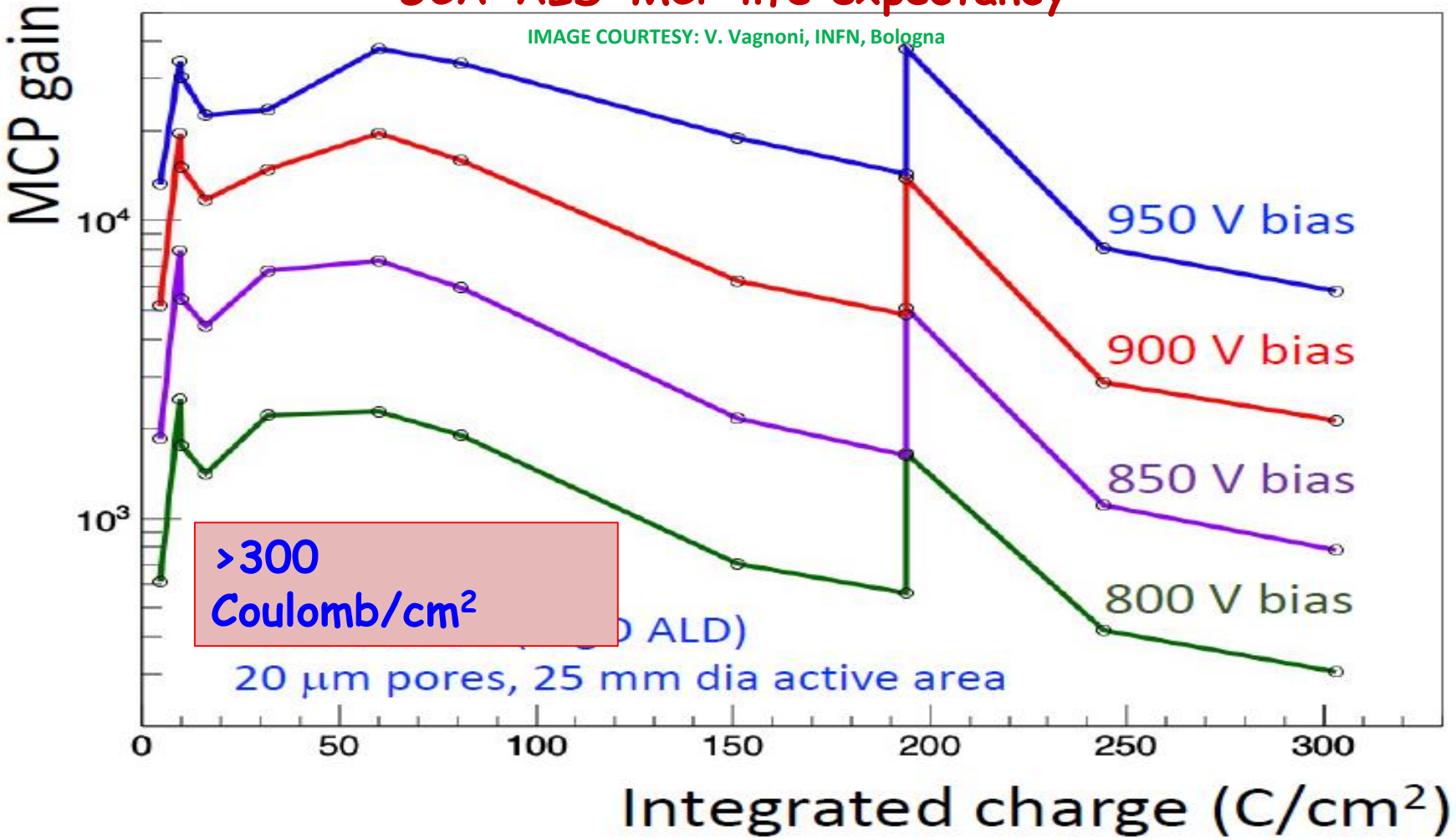
Pulse Height Distribution



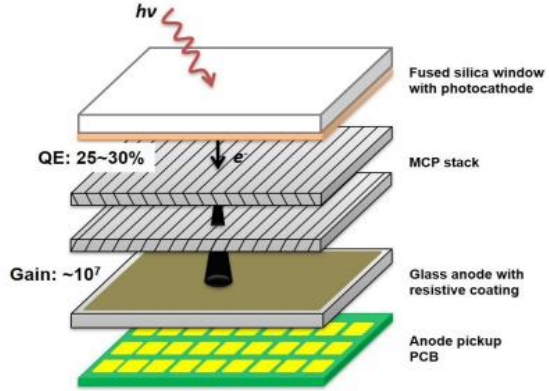
An Update on HRPPD/LAPPD Application Specific Developments for EIC

GCA-ALD-MCP life expectancy

IMAGE COURTESY: V. Vagnoni, INFN, Bologna

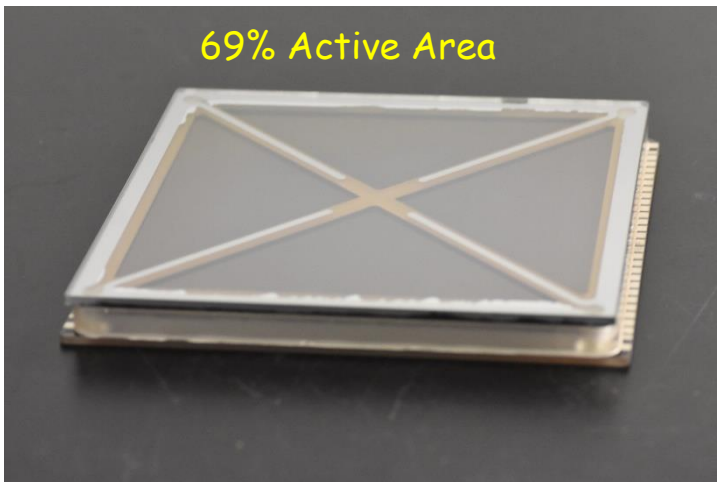


Large Area Picosecond Photon Detector (LAPPD)

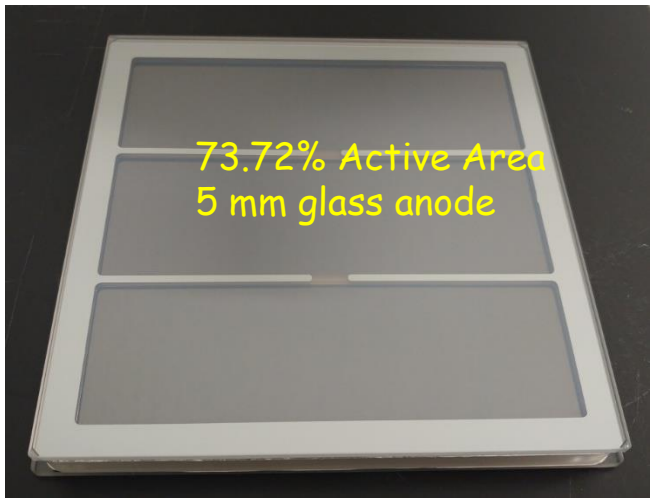


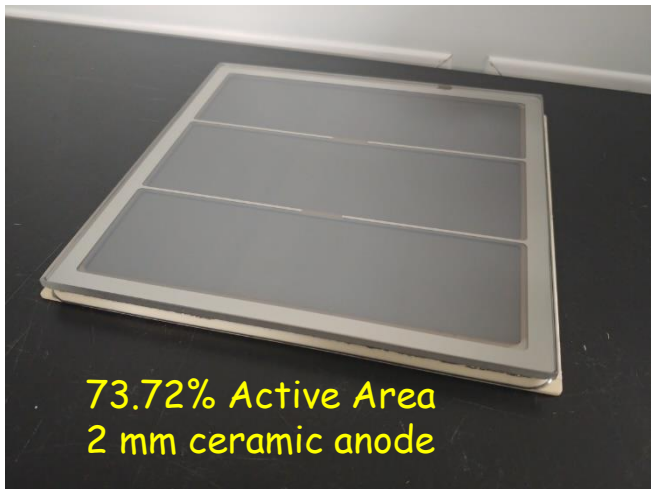
LAPPD evolution:

Glass, Capacitively Coupled Readout, Fused Silica Window



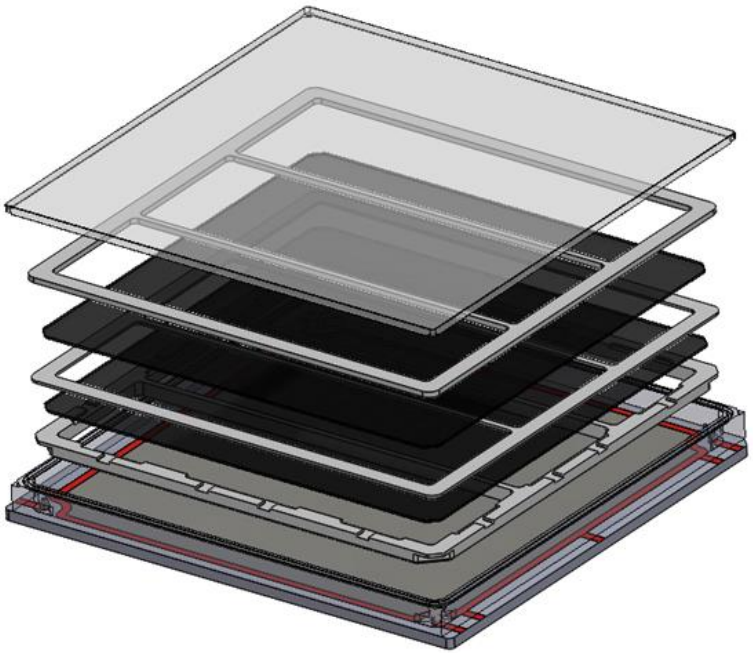
Glass, Stripline Readout, Borosilicate Glass Window

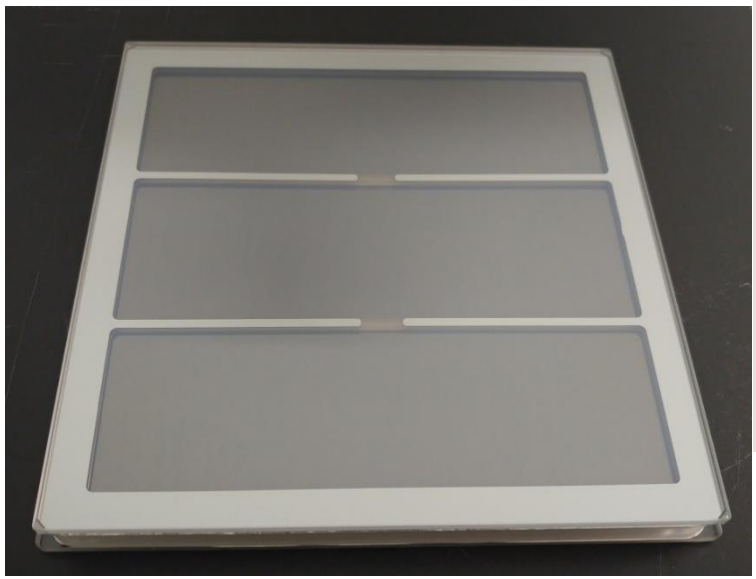




Ceramic, Capacitively Coupled Readout, Fused Silica Window, Reduced Gaps

Capacitively Coupled LAPPDs: typical specs

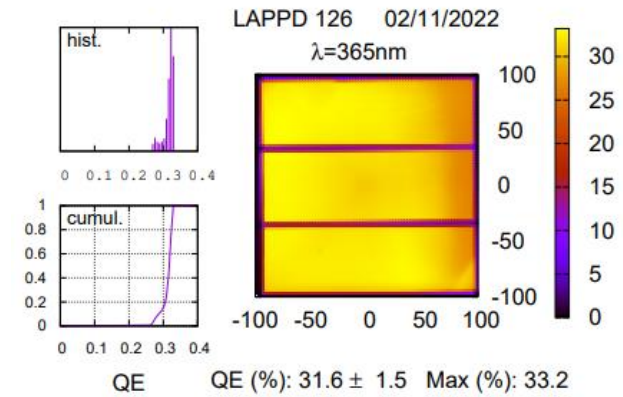


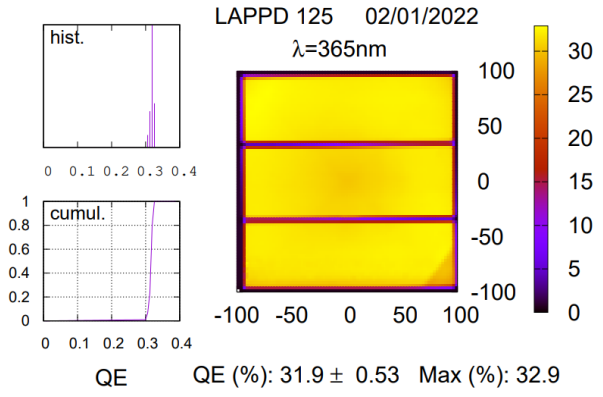


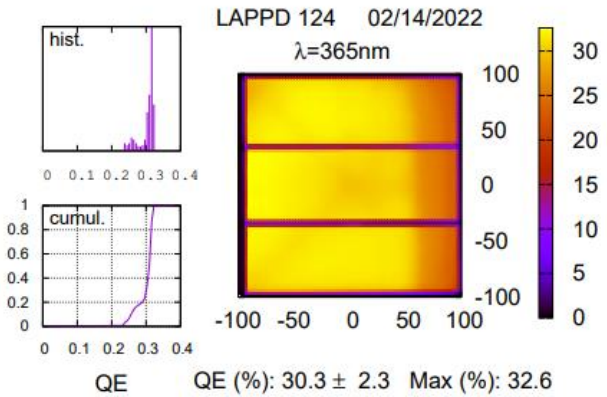
- 20 cm x 20 cm MCP-PMT
  - Chevron pair GCA-ALD-MCPs(10 μm or 20 μm)
  - Glass/Ceramic package
  - 373 cm^2 effective area (~74% active area ratio)
- High Gain (>$5*10^6$)
- Dark Rates: <10kHz/cm^2
- Sodium-Potassium-Antimony Na_2KSb
  - >20% QE at 365 nm
  - >80% spatial uniformity
- Timing Resolution
  - SPE: <100 psec
- Spatial Resolution
  - *O*(mm) (dependent on readout board)
- *Magnetic Field Tolerance up to ~1.4 T

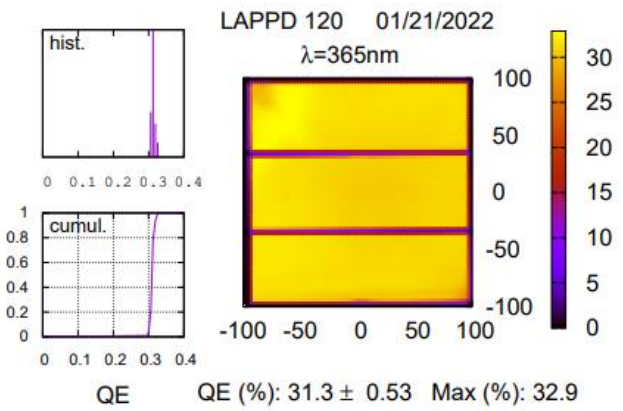
Na_2KSb photocathode development

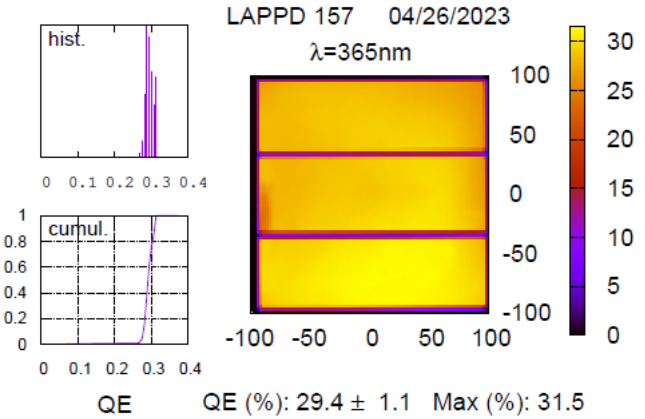
QE of ≥27% and ~80% uniformity consistently achieved!

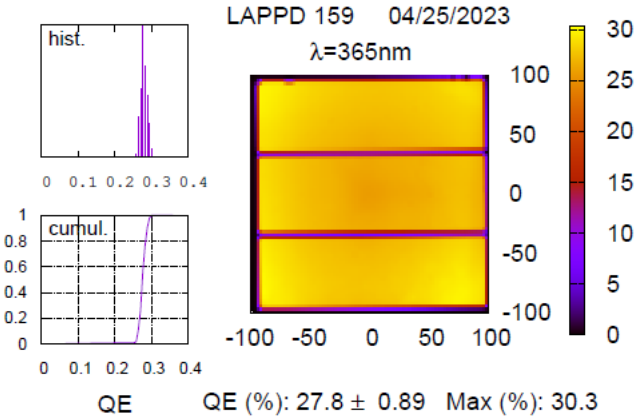






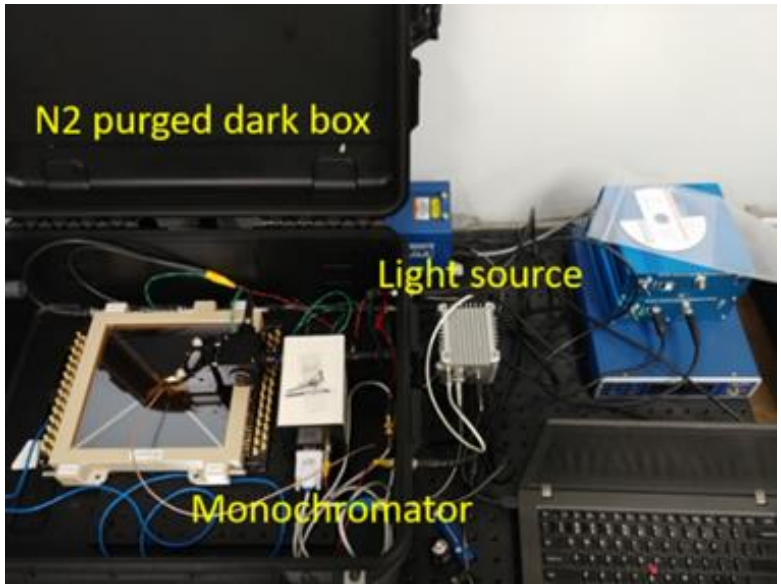


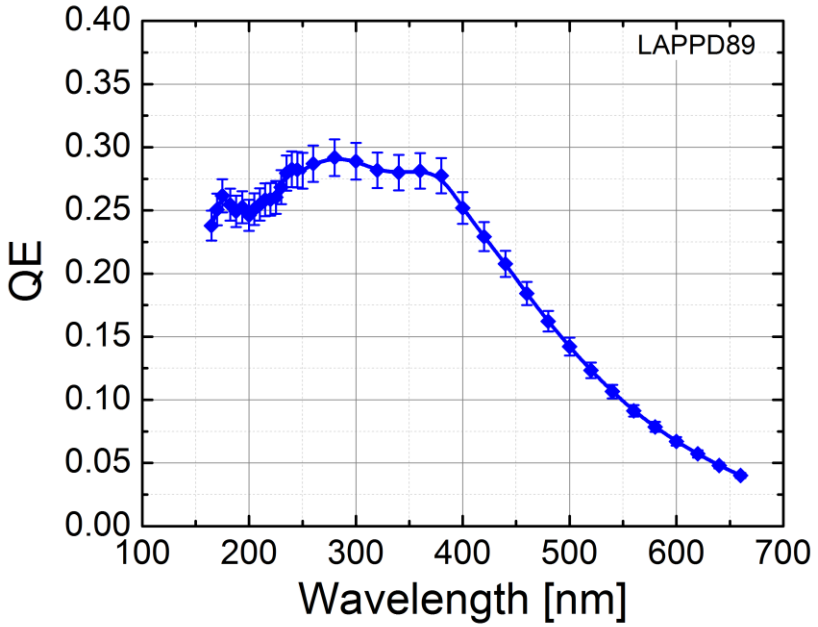


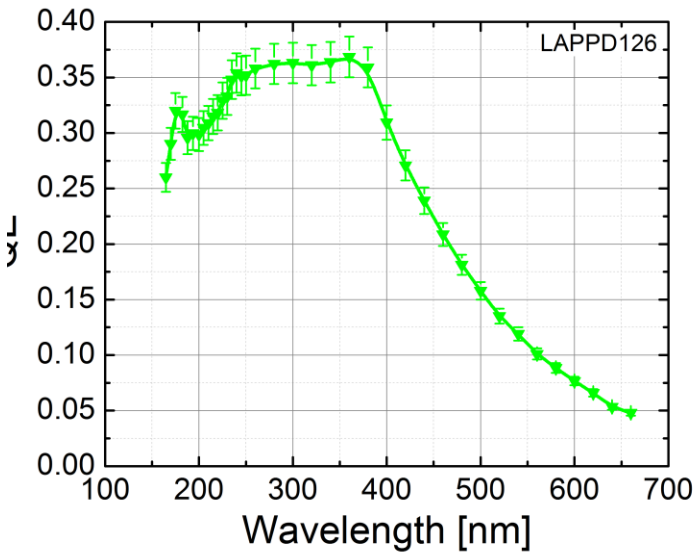


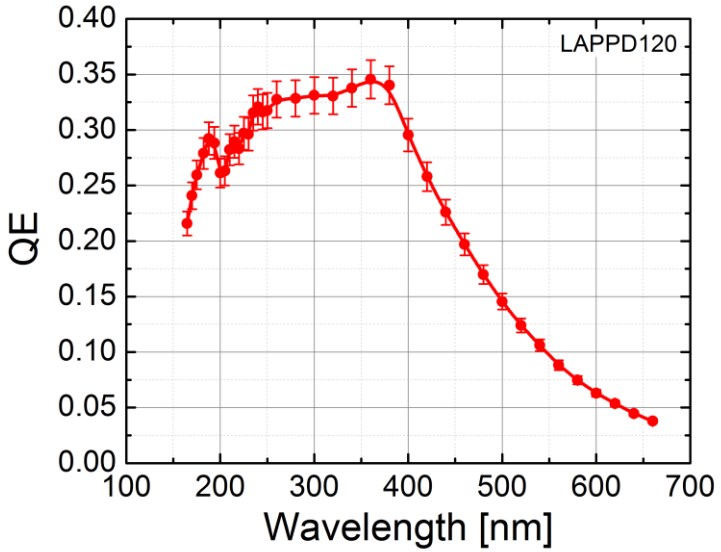
Na_2KSb photocathode development

QE measurement setup with Laser Driven Plasma Light Source



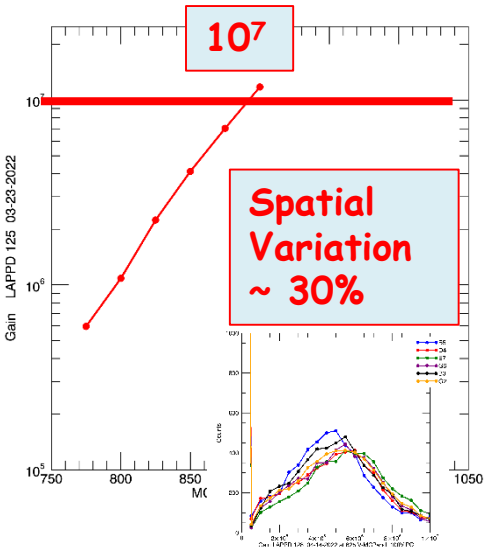




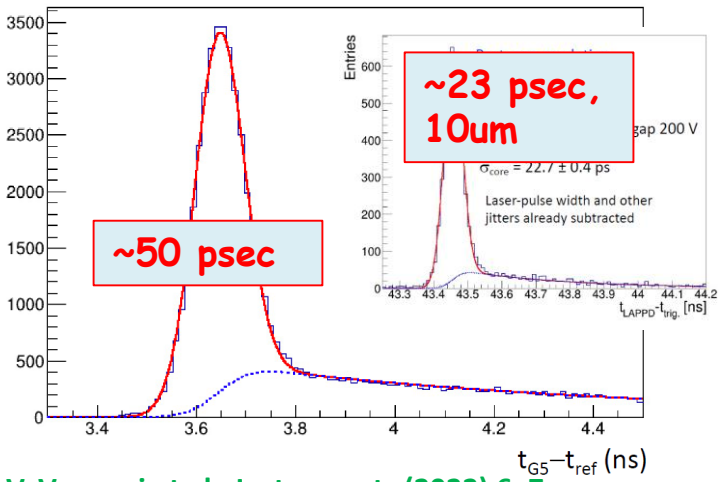


Performance of LAPPD with Capacitively Coupled Readout

Gain

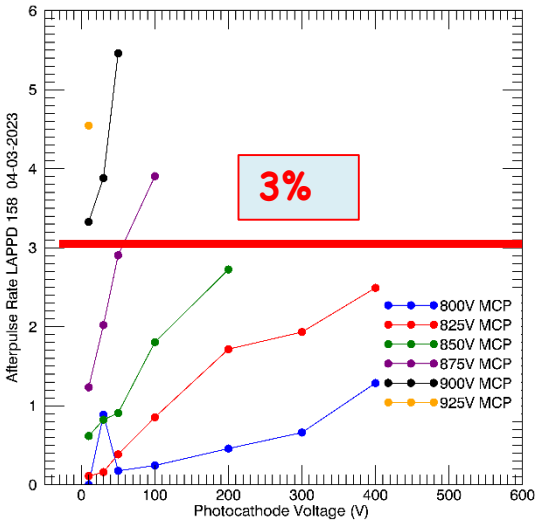


Transit Time Spread

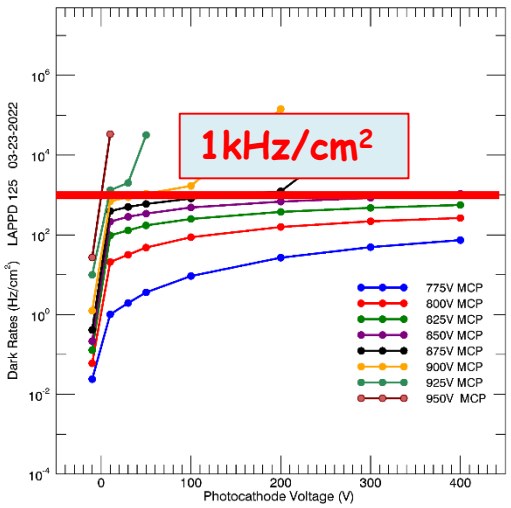


V. Vagnoni et al., Instruments (2022) 6, 7
https://cds.cern.ch/record/2806211/files/document.pdf

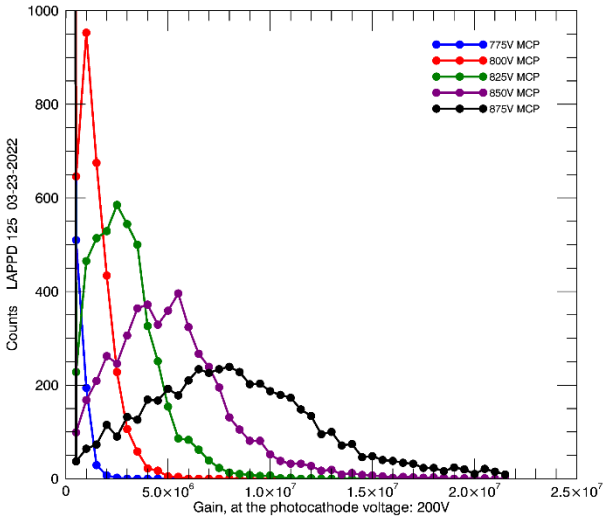
Afterpulsing



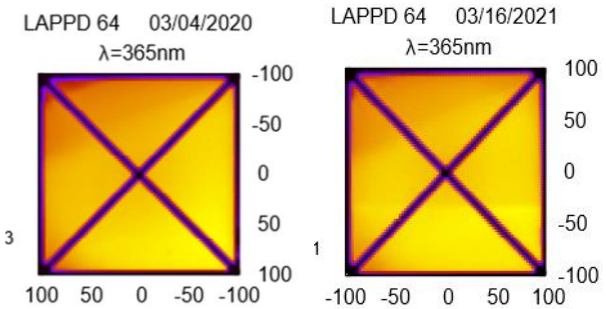
Dark rates



Pulse Height Distribution



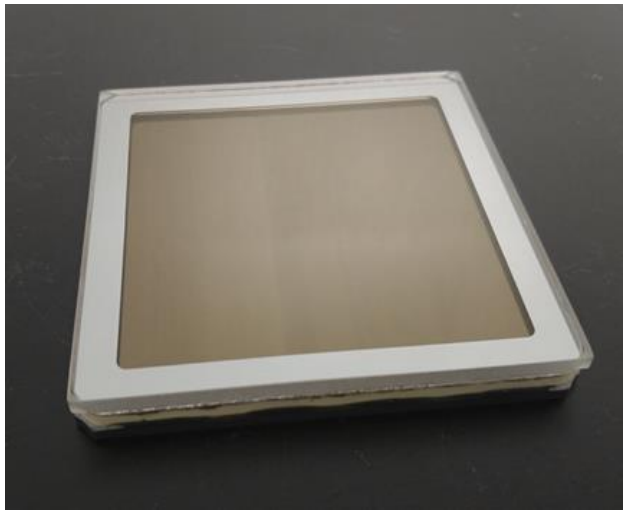
Life-expectancy



No QE degradation after 5.6 C/cm2 @ 5% afterpulse rate

HRPPD – High Rate Picosecond Photodetector

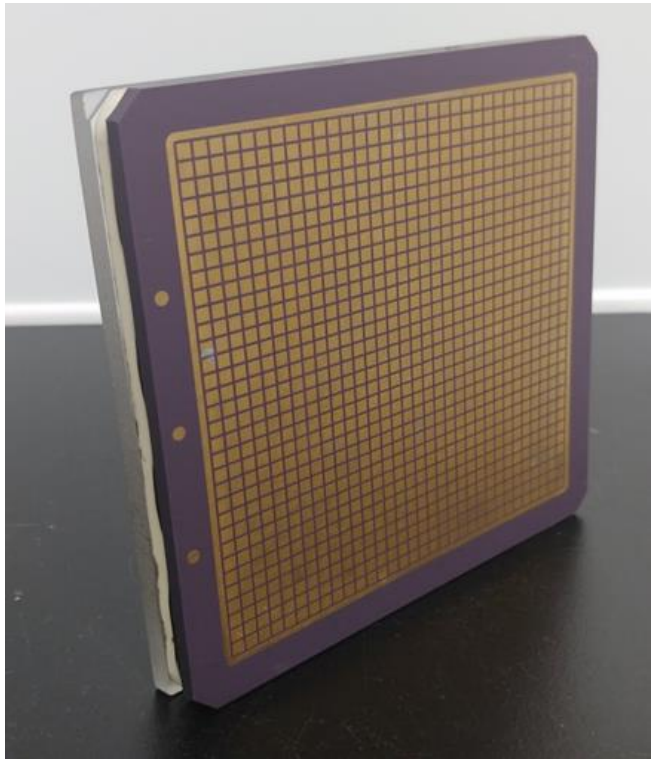
- 10 cm x 10 cm MCP-PMT
Chevron pair GCA-ALD-MCPs (10 μm)
Ceramic package
Capacitive (CC) or Direct (DC) Coupling
100 cm^2 active area



- High Gain ($5*10^6$)

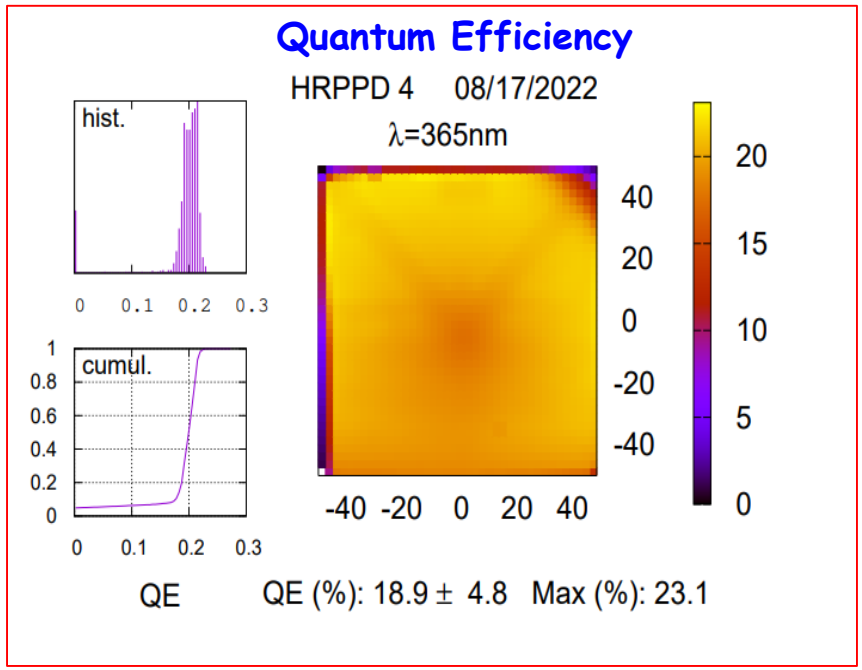
Dark Rates: <10kHz/cm^2

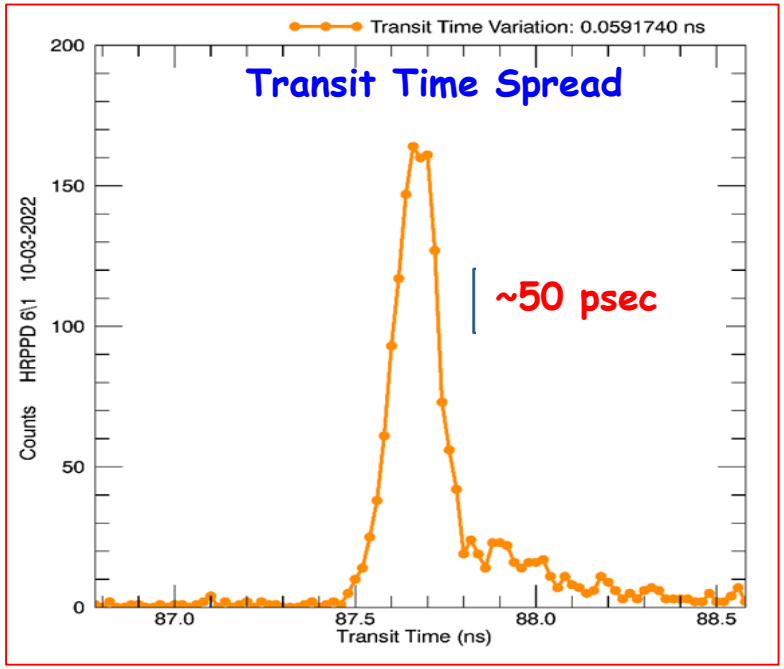
- Photocathode Na_2KSb
  - >20% QE at 365 nm
  - >80% spatial uniformity

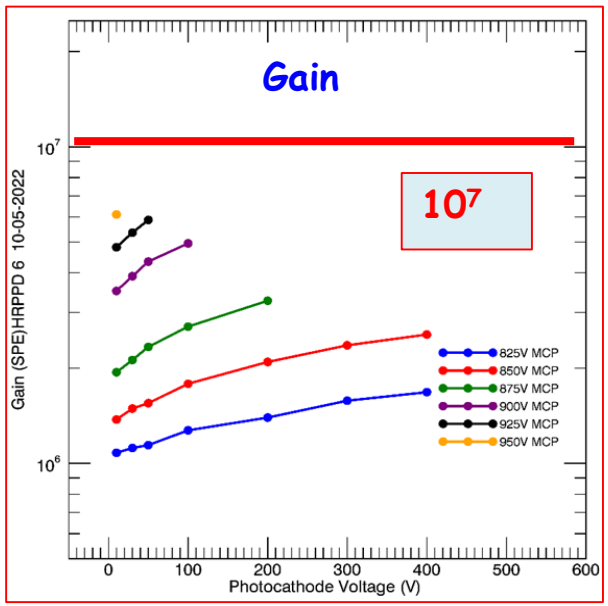


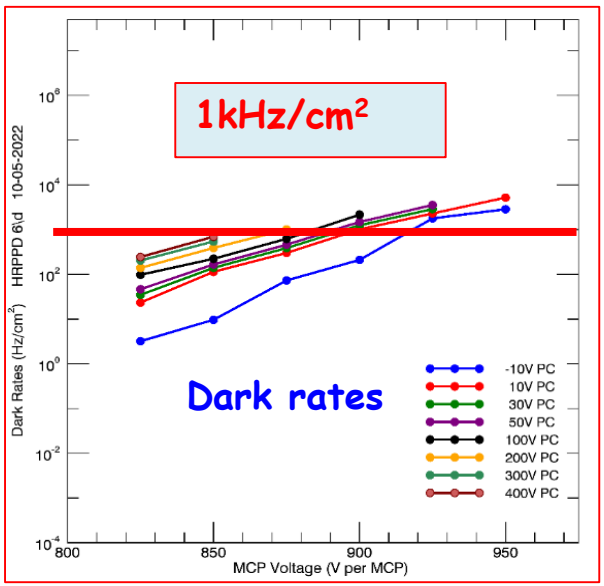
- Timing Resolution
  - SPE: <50 psec
- Position Resolution (TBD)

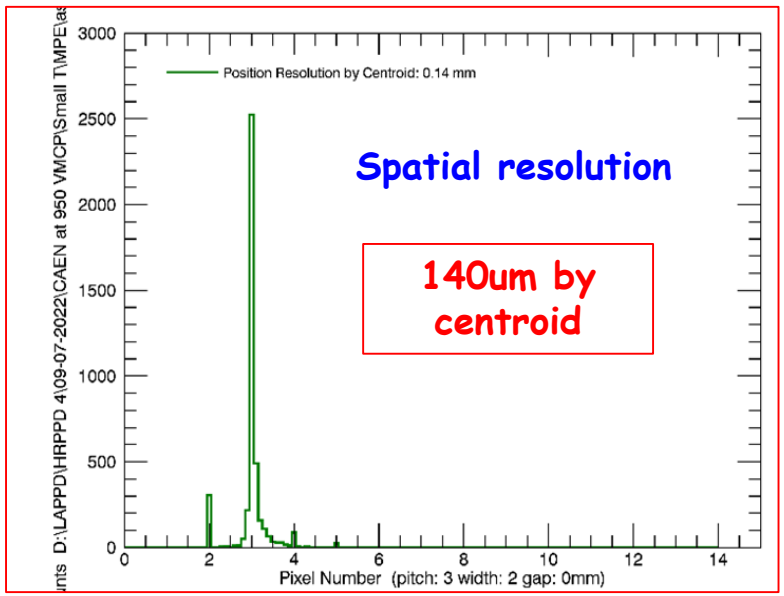
HRPPD Performance





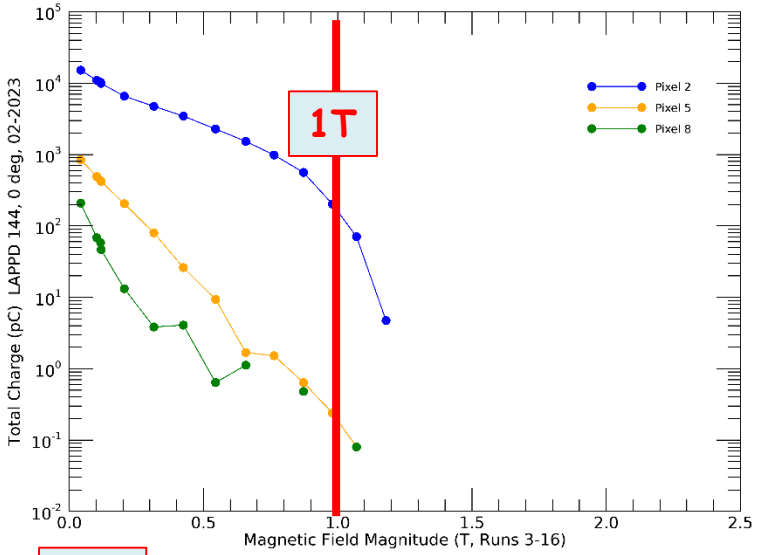




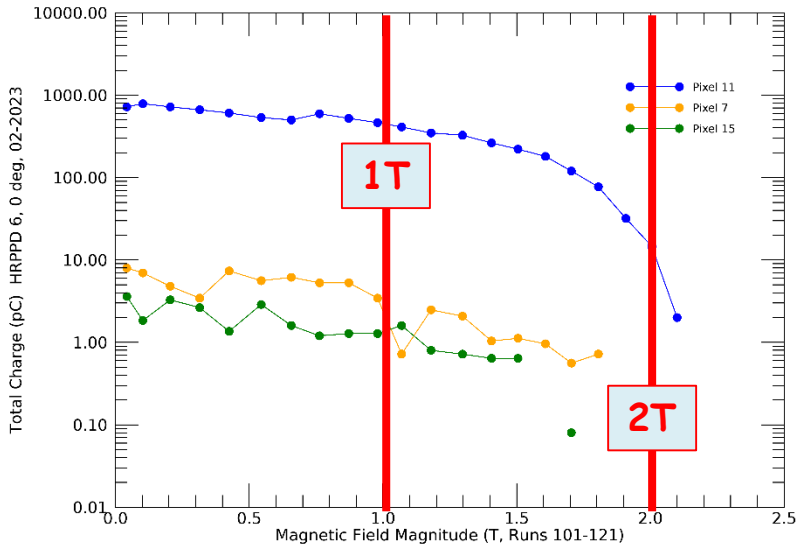


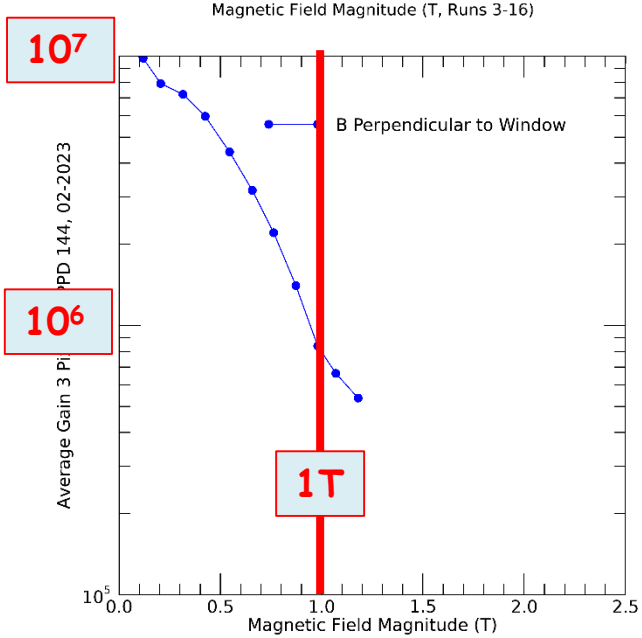
HRPPD Performance in B-field

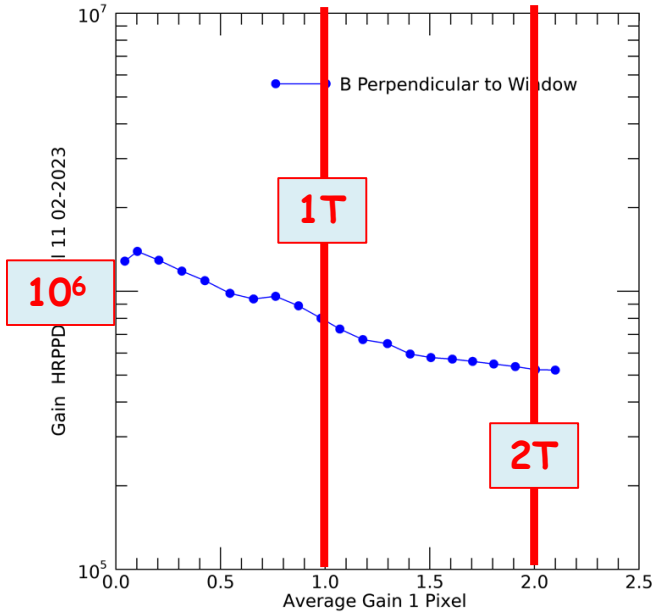
LAPPD



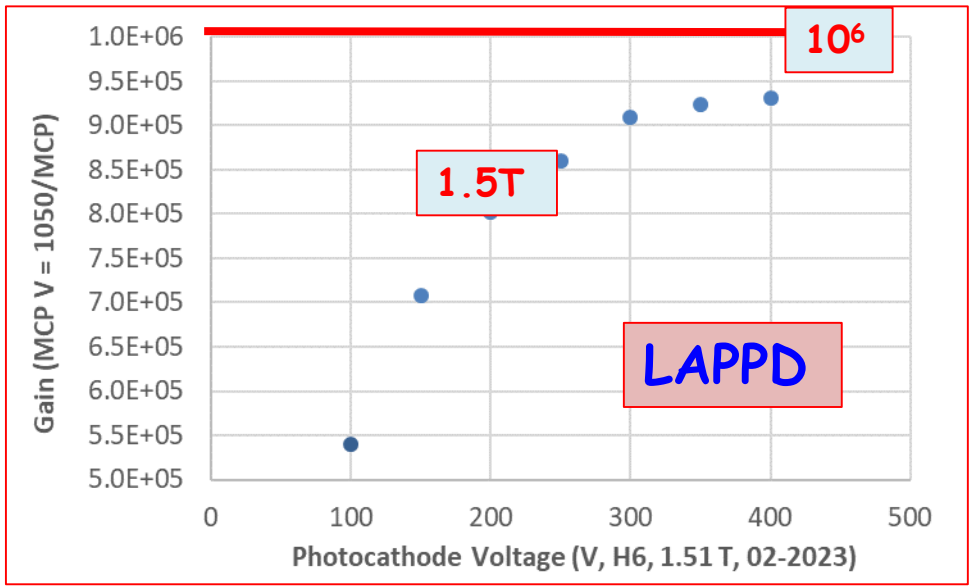
HRPPD

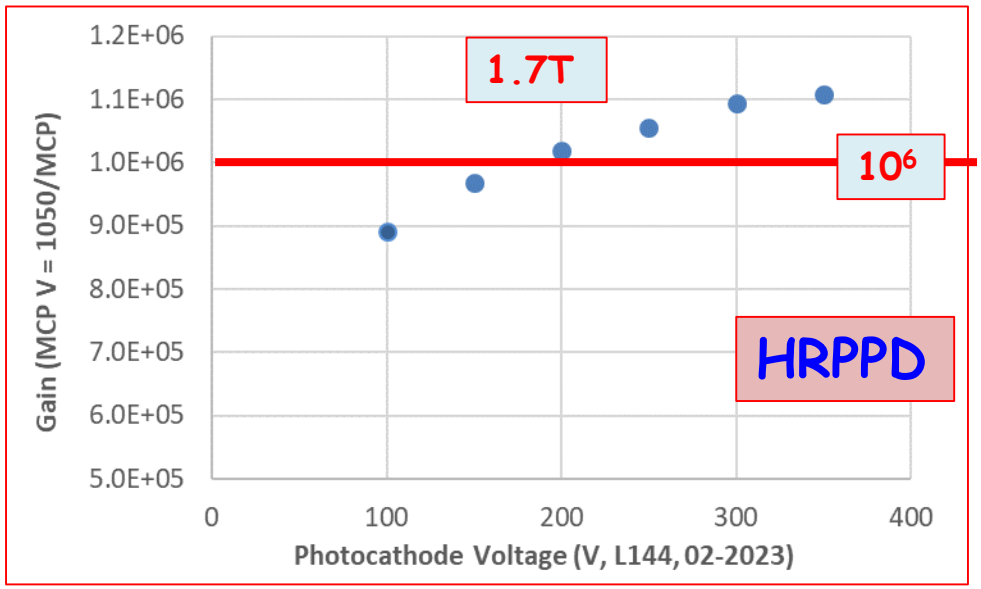


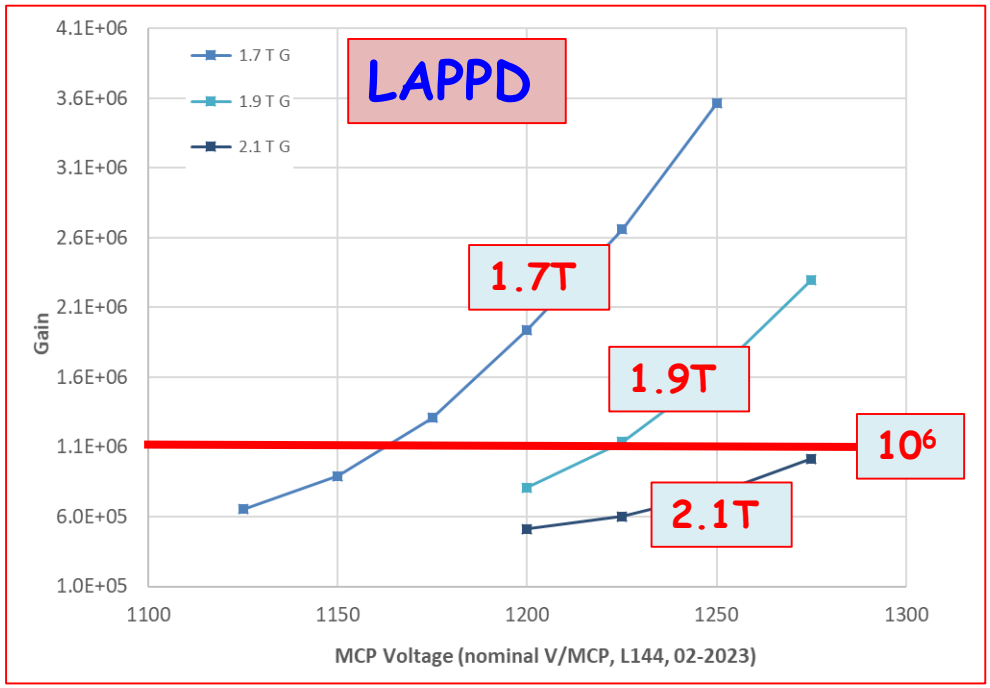


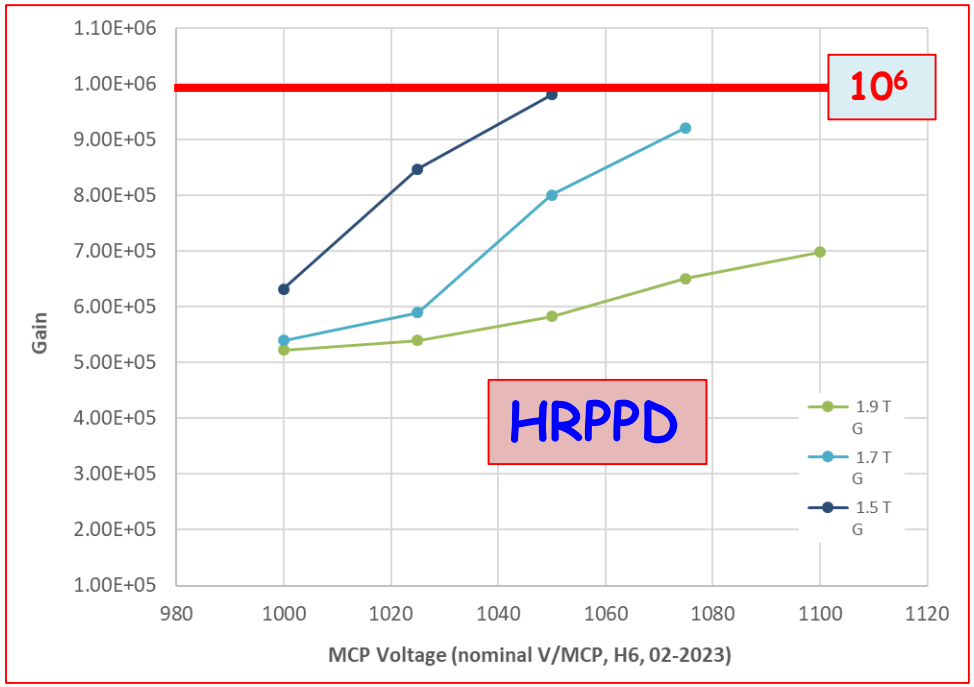


HRPPD Performance in B-field: Gain Recovery









LAPPD EIC Workshops

2023

https://indico.bnl.gov/event/18642/

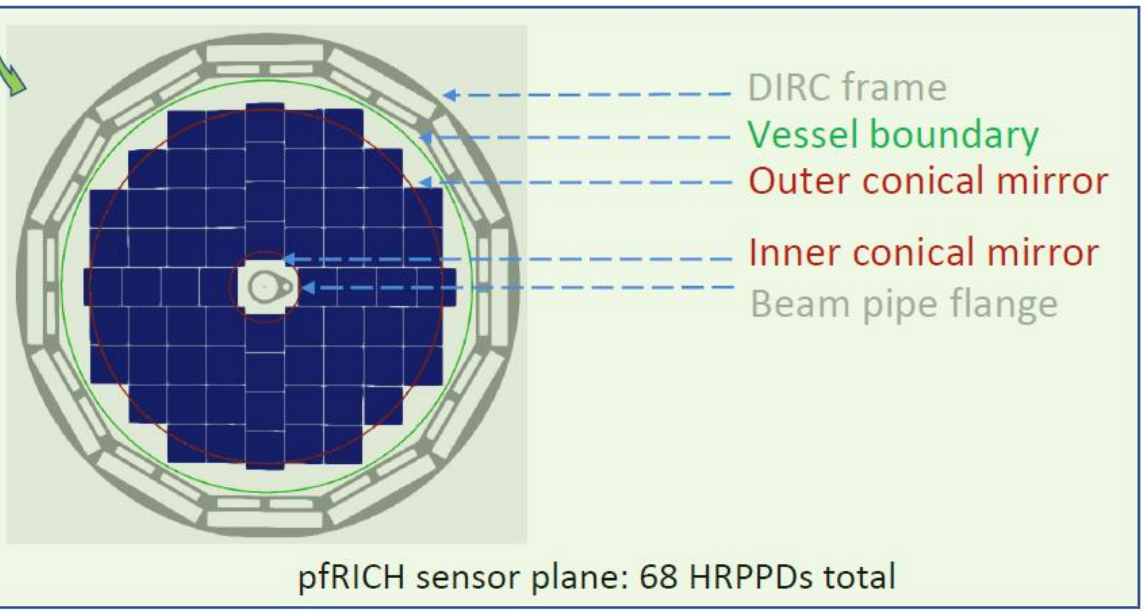
2022

https://indico.bnl.gov/event/17475/

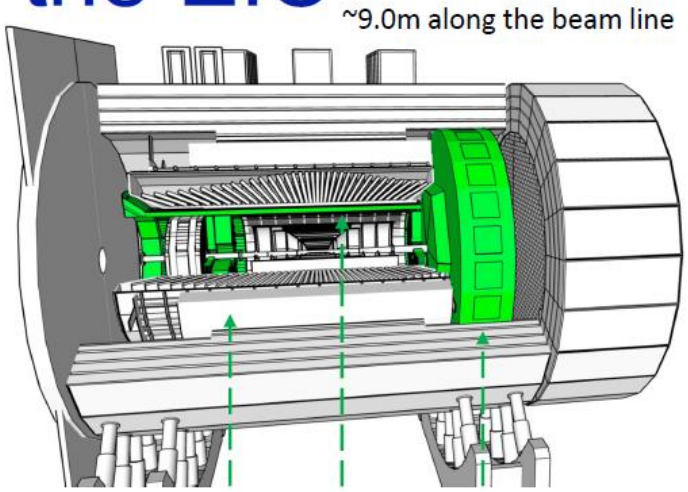
Possible LAPPD applications for the EIC

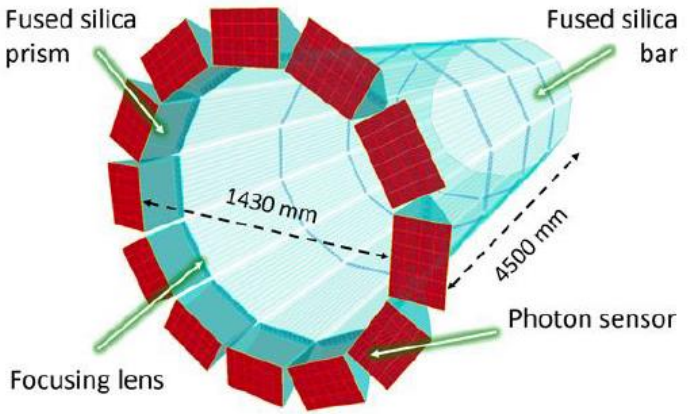
- Backward RICH: low dark noise, ToF capability (vs SiPMs)
  - LAPPD is a baseline photosensor as of November 2022
- DIRC: expected to be more cost-efficient (vs other MCP-PMTs)
- dRICH: problematic, because of the magnetic field orientation

Backward RICH	either DC-coupled or Gen II, 10cm formfactor
DIRC	DC-coupled, 10cm



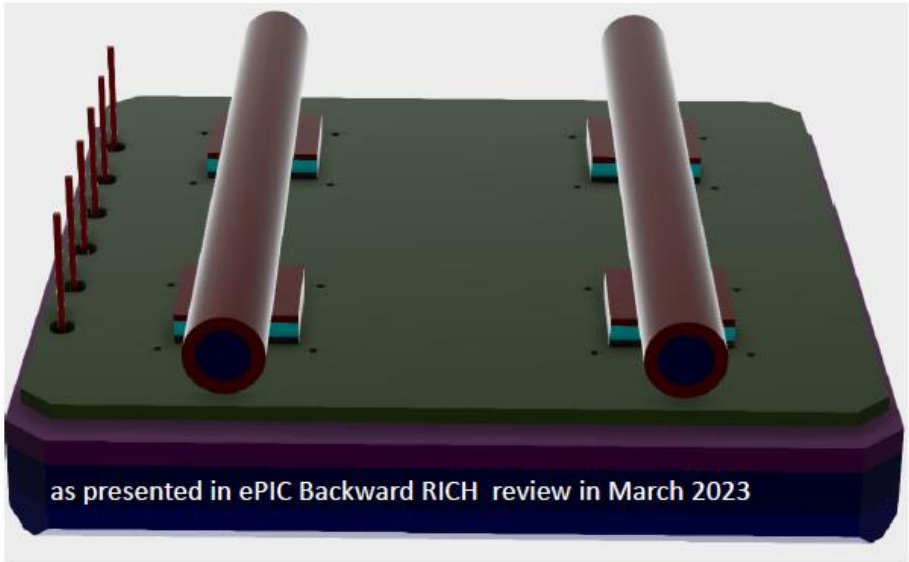
pfRICH sensor plane: 68 HRPPDs total





DIRC: 12*3*2 = 72 HRPPDs total

Slide Courtesy A. Kiselev, 2023 BNL LAPPD workshop https://indico.bnl.gov/event/18642/



- DC-coupled HRPPDs
- 32x32 pad pixellation
- TOA / TOT(ADC) ASIC
- Flat integration

Image Courtesy A. Kiselev, 2023 BNL LAPPD workshop https://indico.bnl.gov/event/18642/

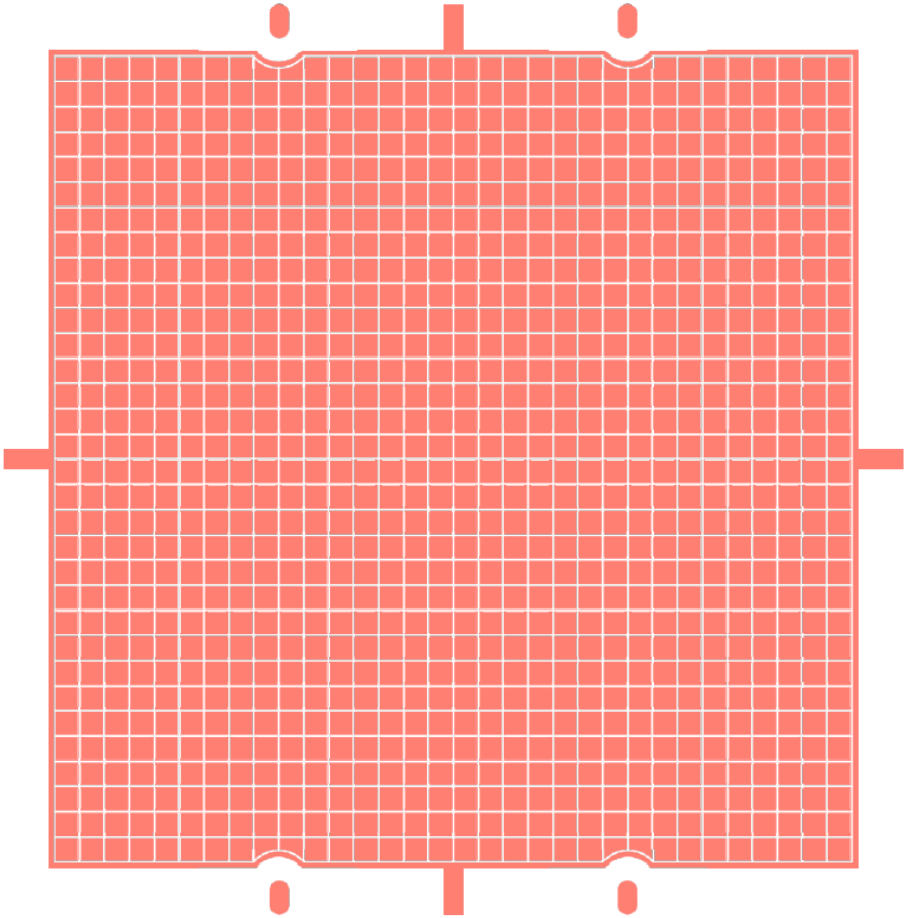
HRPPD EIC ePIC Specific Detector Development

Project Schedule

Task	2023											
	Jan	Feb	Mar	Apr	May (now)	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0. Project Management												
1. Window to Ceramic Sealing (60%)												
2. Anode Design and Fabrication (50%)												
3. Internal Connections (80%)												
4. Internal Components Design and Procurement (80%												
5. Readout Board Design (50%)												
6. Performance/Process Optimized (50%)												
7. BNL/EIC Tile Test Plans												
8. Fabricate 5 HRPPDs for EIC delivery												

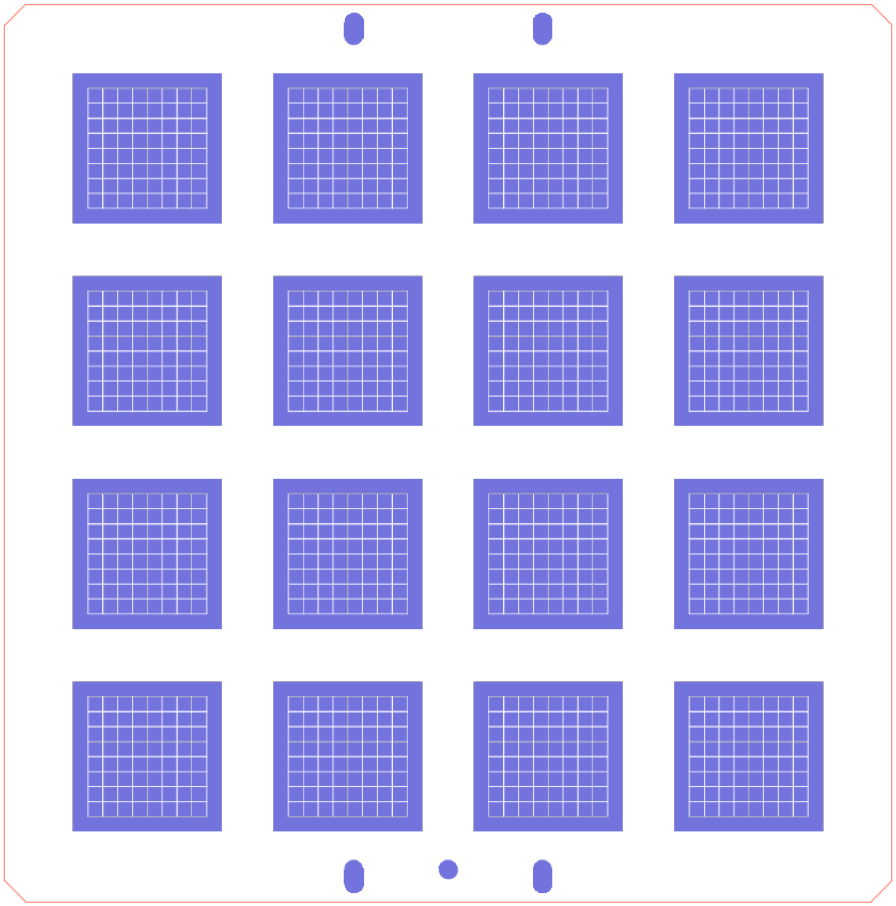
HRPPD Anode Development

Vacuum Side

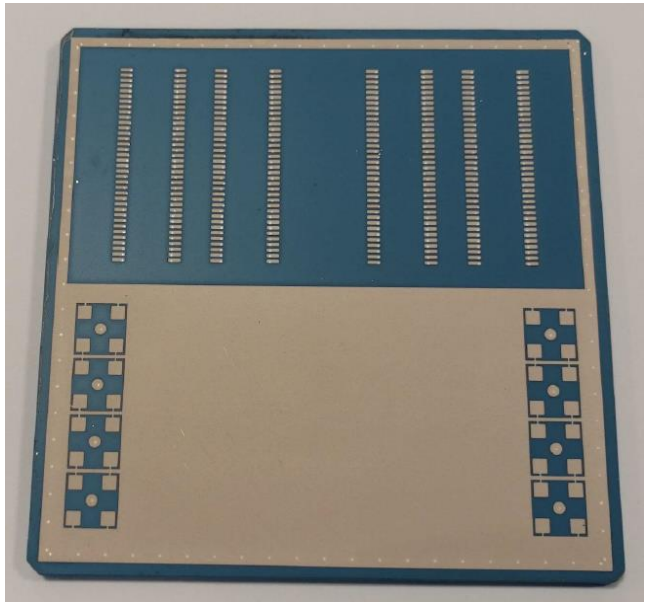


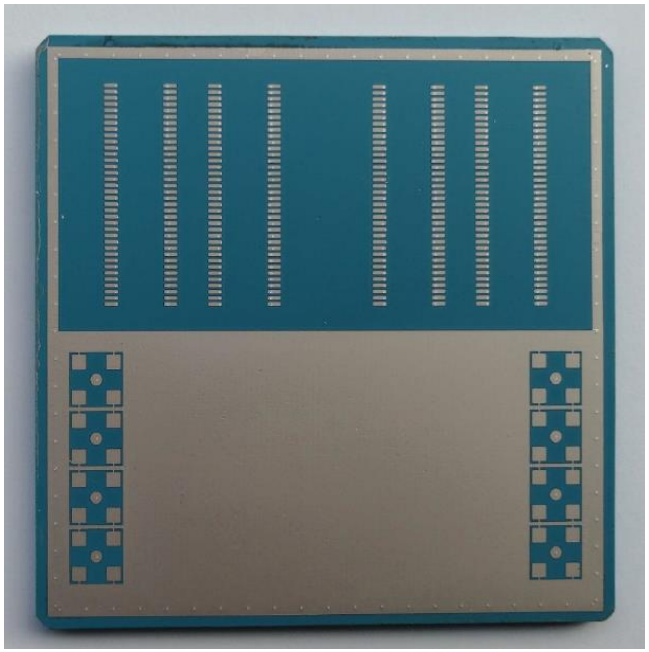
32X32 pads

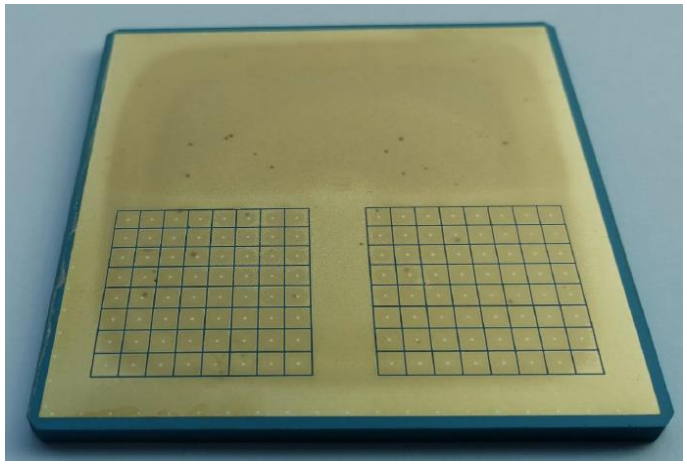
Air Side

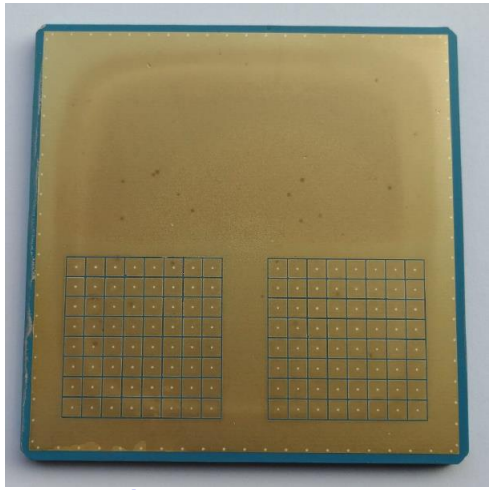


Two Test Anodes Fabricated by Techtra







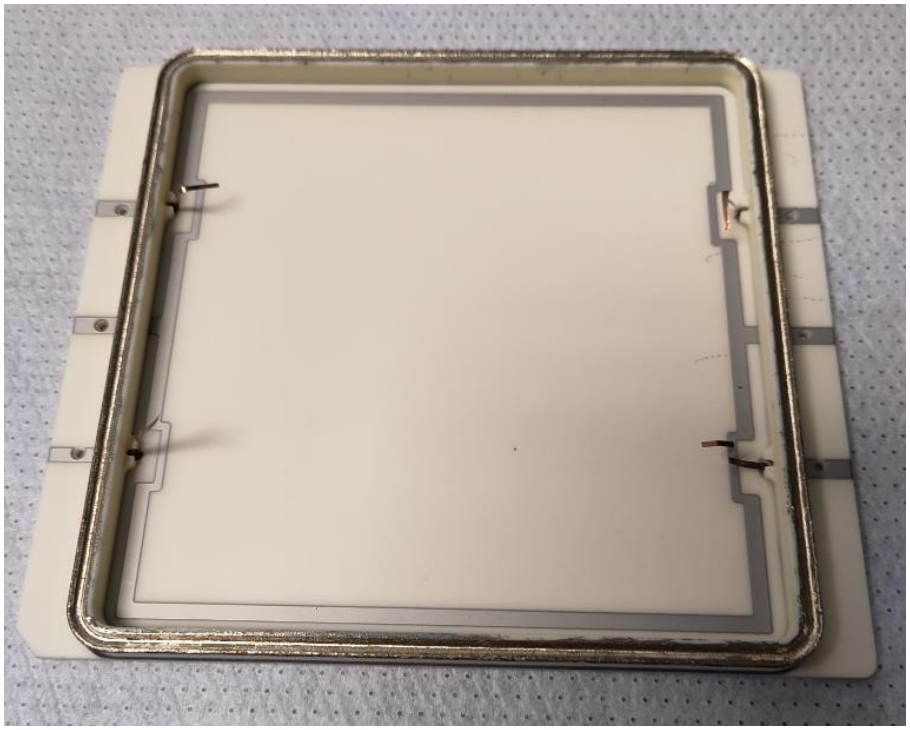


Electrical integrity verified

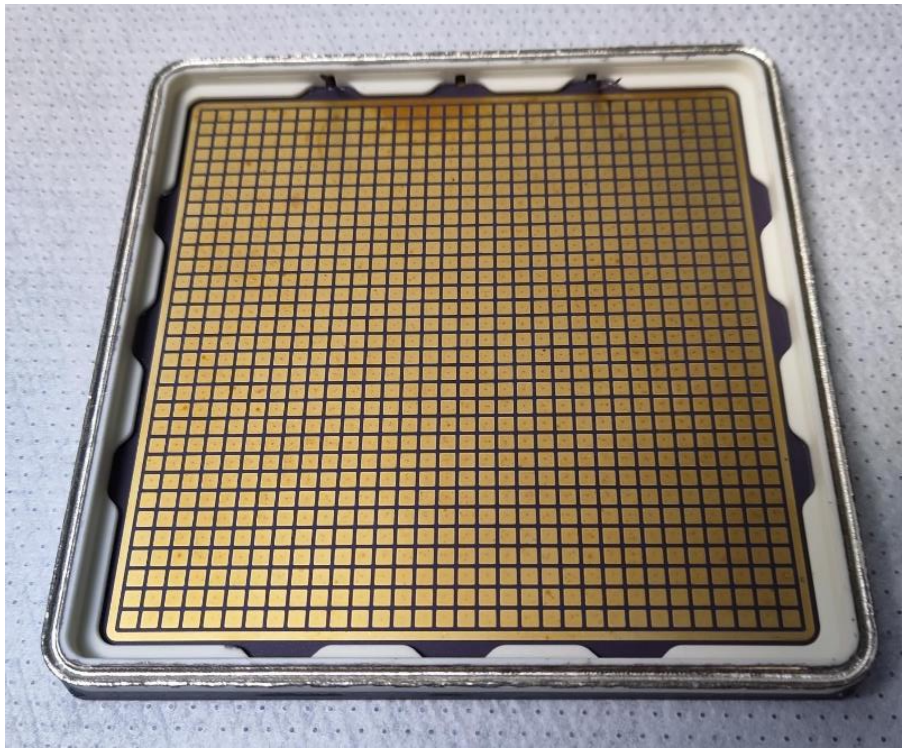
Trace capacitance have been measured to be within 10pF

Ceramic HRPPD packages

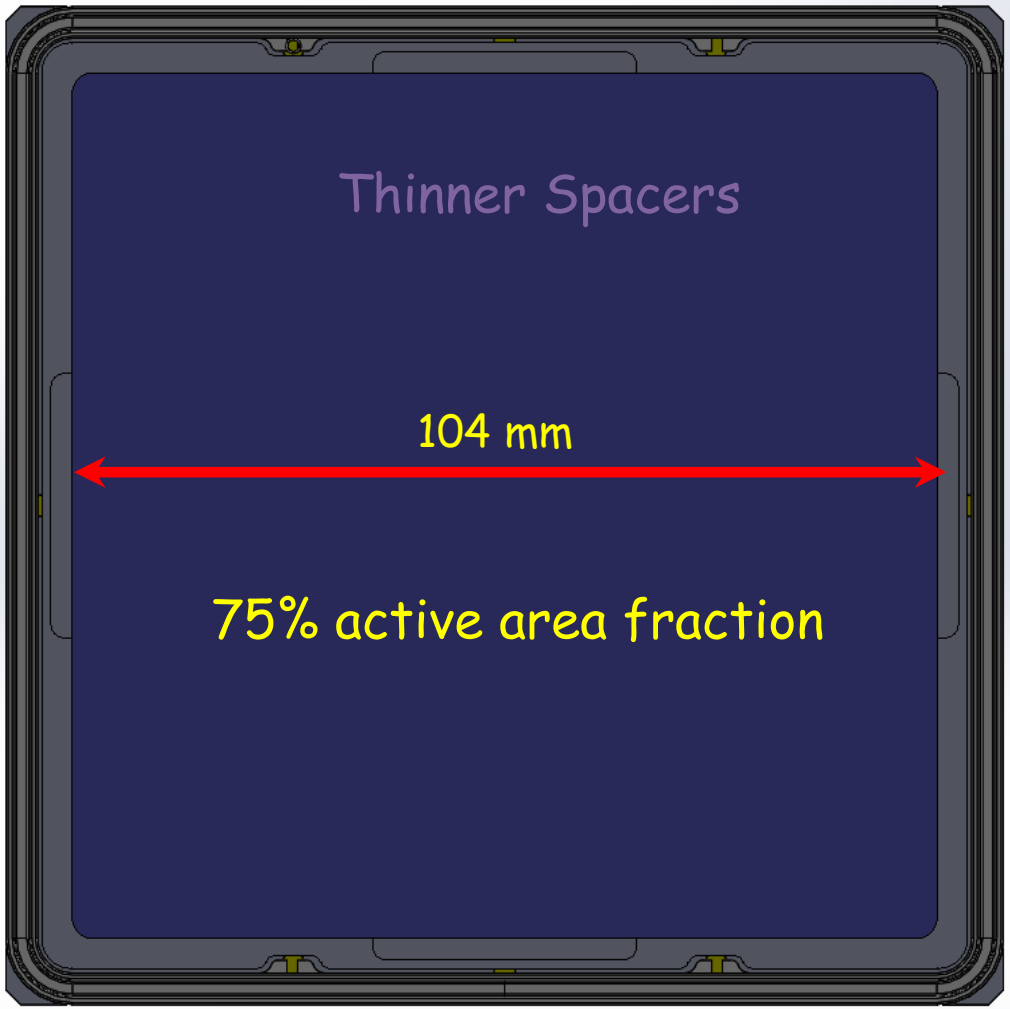
Capacitively Coupled

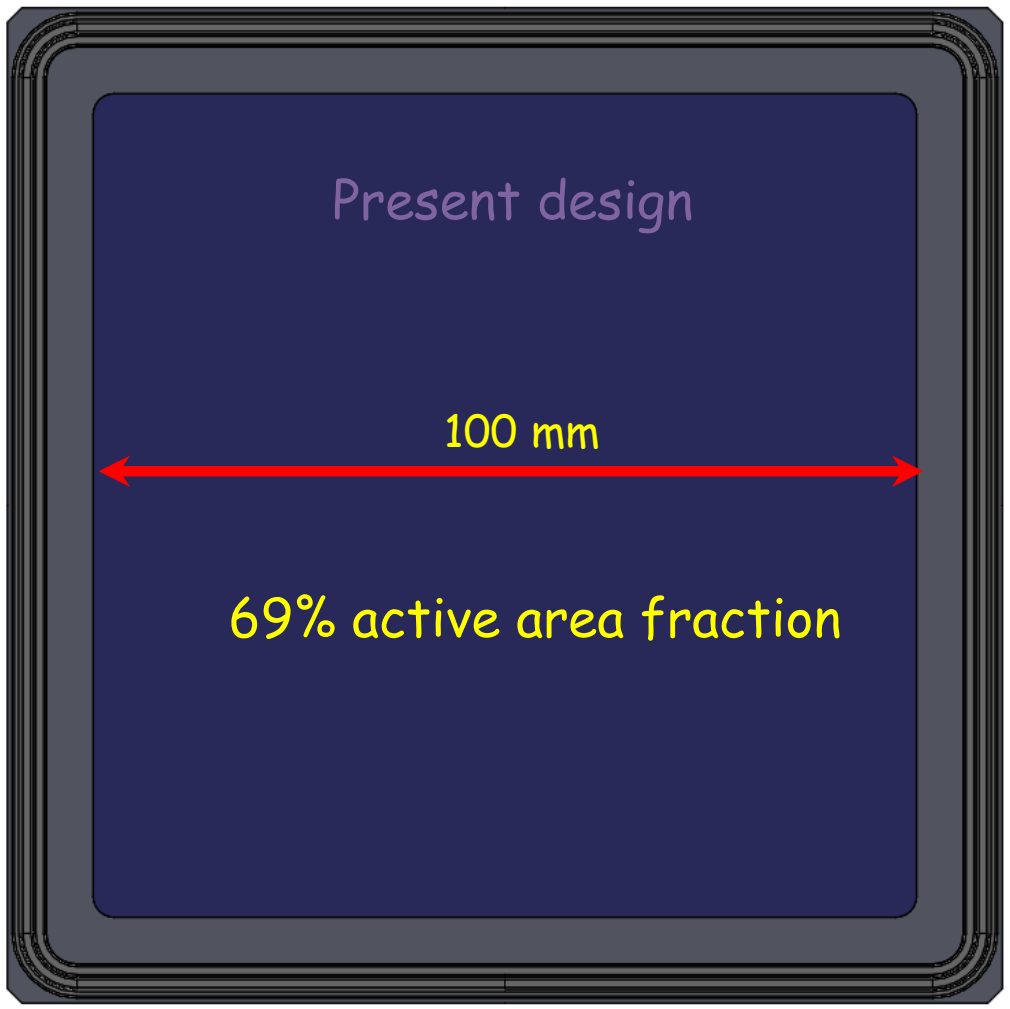


Directly Coupled



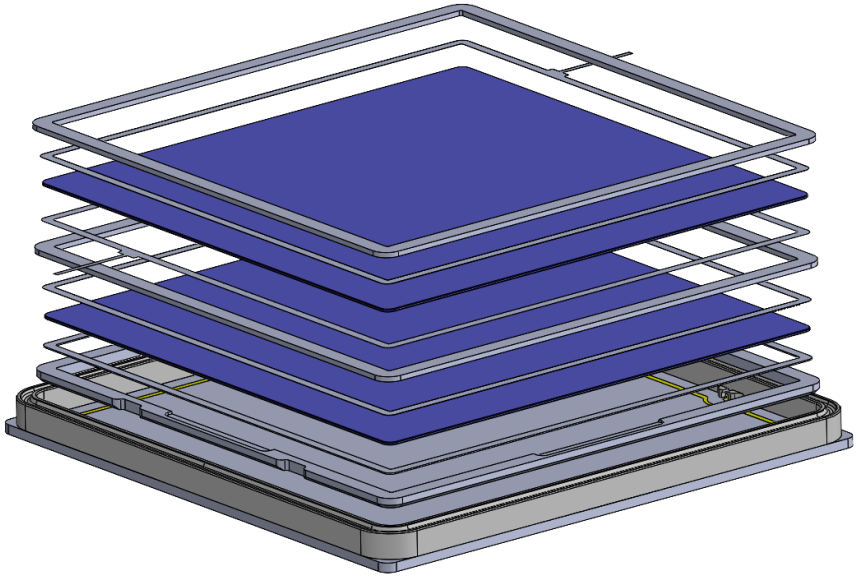
HRPPD active area

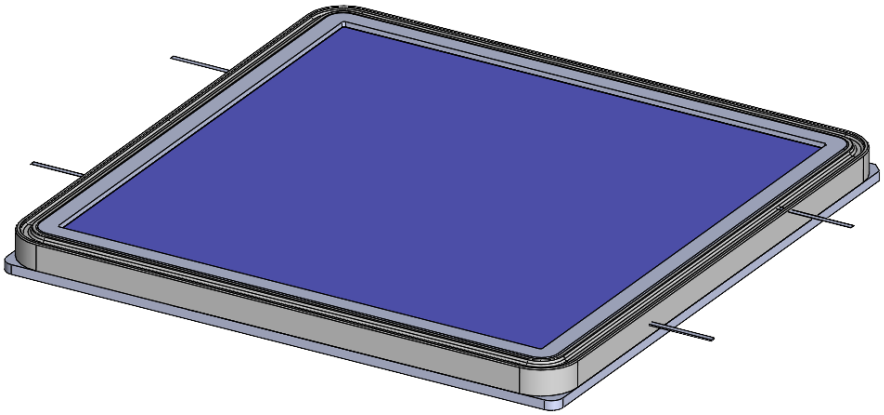


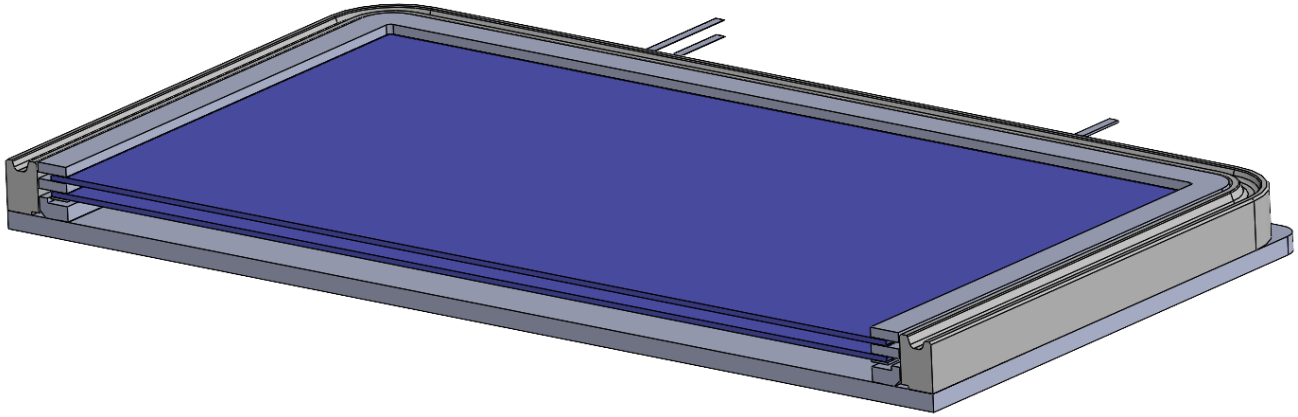


HRPPD active area

Gapped MCPs design

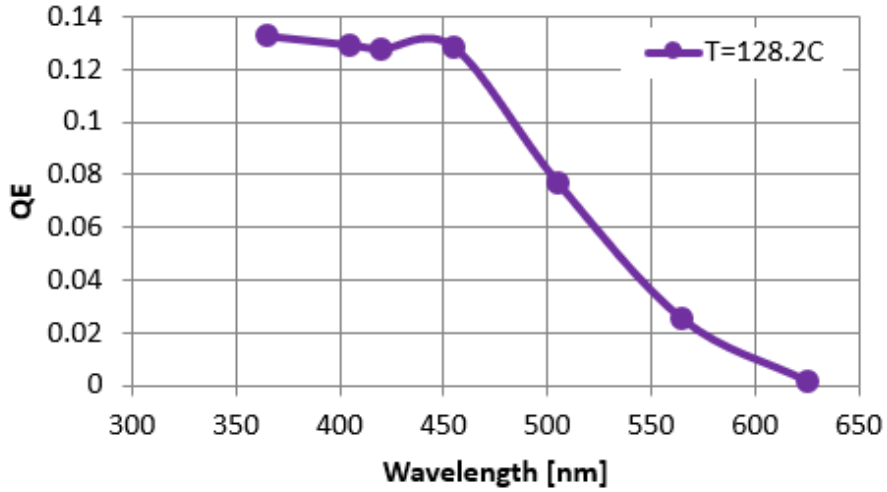


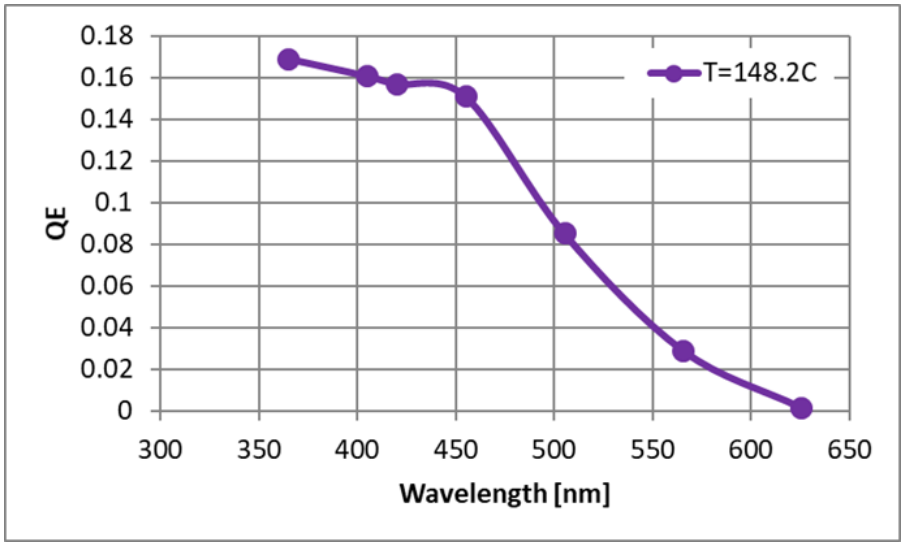




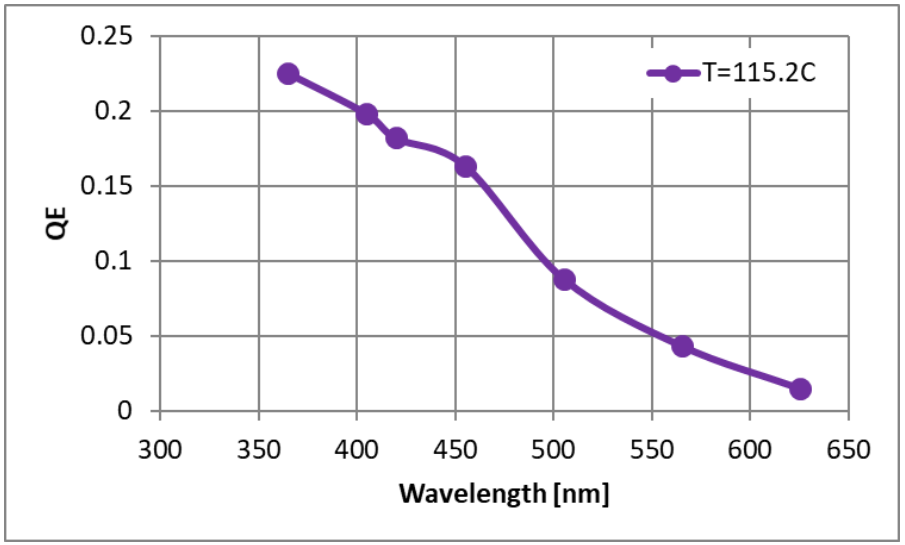
Rb-K-Cs-Sb photocathode trials

Rb-K-Cs-Sb



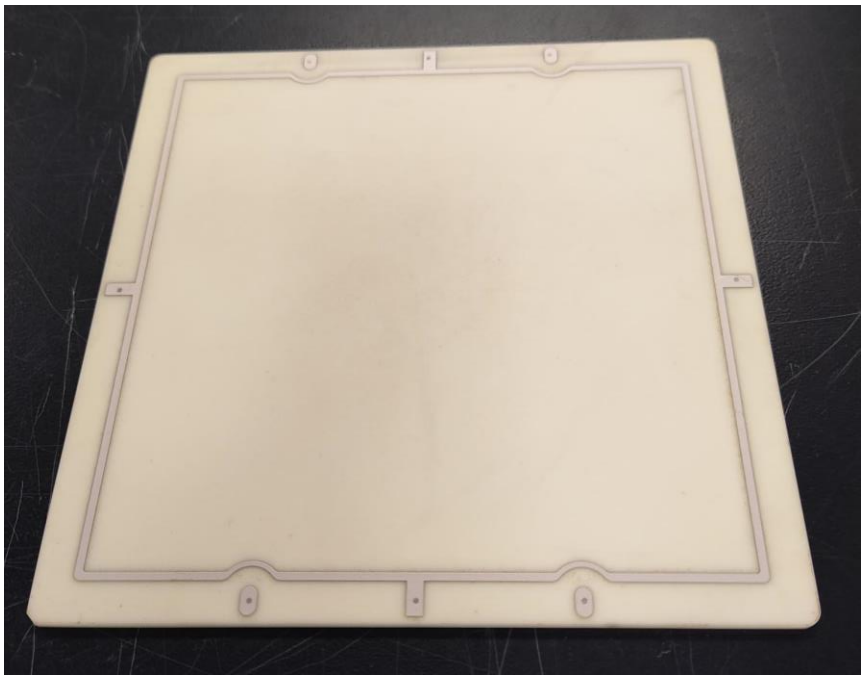


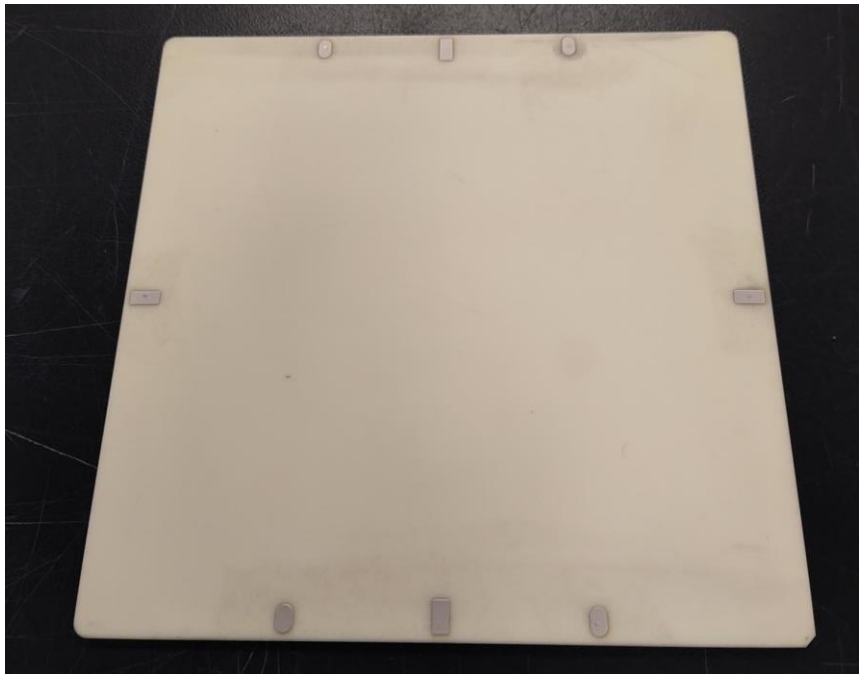
Na_2KSb

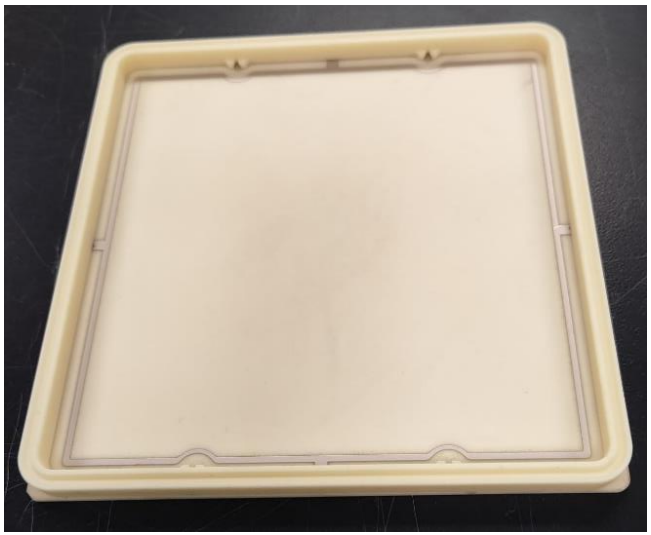


Tilability

Tilable capacitively coupled anode (75% OAR)







Summary

- LAPPD is an established photosensor technology
- HRPPD for EIC is being developed
- Magnetic field tests performed up to 2T. Gain 10^6 is achievable at 2T.
- Manufacturing of first tiles for EIC will start in August